This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Claim 1 (canceled)

Claim 2 (previously presented): A method of modifying a semiconductor compound or alloy comprising host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising:

isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors, such that content of the first isoelectronic dopant in the semiconductor compound or alloy is more than 1 at.% and content of the second isoelectronic dopant in the semiconductor compound or alloy is more than 1 at.%.

Claim 3 (original): The method of claim 2, wherein the semiconductor compound or alloy comprises Group III and V host atoms.

Claim 4 (original): The method of claim 3, wherein the first isoelectronic dopant comprises Group V or Group III atoms and the second isoelectronic dopant comprises Group V or Group III atoms.

Claim 5 (original): The method of claim 4, wherein the Group III and V host atoms comprise Ga and As.

Claim 6 (original): The method of claim 5, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 7 (original): The method of claim 6, wherein content of the N in the semiconductor compound or alloy is more than 3 at.% and content of the Bi in the semiconductor compound or alloy is more than 3 at.% of the crystal lattice.

Claim 8 (original): The method of claim 4, wherein the Group III and V host atoms comprise In and P.

Claim 9 (original): The method of claim 8, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 10 (original): The method of claim 9, wherein content of the N in the semiconductor compound or alloy is more than 3 at.% and content of the Bi in the semiconductor compound or alloy is more than 3 at.%.

Claim 11 (original): The method of claim 4, wherein the Group III and V host atoms comprise Ga and P.

Claim 12 (original): The method of claim 11, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 13 (original): The method of claim 4, wherein the Group III and V host atoms comprise Al, Ga, and P.

Claim 14 (original): The method of claim 13, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 15 (original): The method of claim 4, wherein the Group III and V host atoms comprise In, Ga, and As.

Claim 16 (original): The method of claim 15, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 17 (original): The method of claim 2, wherein the semiconductor compound or alloy comprises Group II and VI host atoms.

Claim 18 (original): The method of claim 17, wherein the first isoelectronic dopant comprises Group VI atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 19 (original): The method of claim 17, wherein the semiconductor alloy comprises Zn and Se host atoms.

Claim 20 (original): The method of claim 18, wherein the first isoelectronic dopant comprises O and the second isoelectronic dopant comprises Te.

Claim 21 (original): The method of claim 17, wherein the first isoelectronic dopant comprises Group II atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 22 (original): A method of modifying a Group III - V semiconductor compound or alloy to have a lower effective bandgap than the Group III - V semiconductor compound or alloy has prior to modification, comprising:

isoelectronically co-doping the Group III - V compound or alloy with more than 1 at.% of a deep acceptor element and more than 1 at.% of a deep donor element.

Claim 23 (original): The method of claim 22, including isoelectronically co-doping the Group III - V compound or alloy with more than 3 at.% of a deep donor element and more than 3 at.% of a deep acceptor element.

Claim 24 (original): The method of claim 22, wherein the deep acceptor element is a Group V element and the deep donor element is a group V element.

Claim 25 (original): The method of claim 24, wherein the Group III - V semiconductor alloy comprises GaAs, the deep acceptor element is N, and the deep donor element is Bi.

Claim 26 (original): The method of claim 24, wherein the Group III - V semiconductor alloy comprises InP, the deep acceptor element is N, and the deep donor element is Bi.

Claim 27 (original): The method of claim 24, wherein the Group III - V semiconductor alloy comprises GaP.

Claim 28 (original): The method of claim 27, wherein the deep acceptor element is N and the deep donor element is Bi.

Claim 29 (canceled)

Claim 30 (previously presented): A semiconductor material for use as an active cell in a semiconductor device, the material comprising:

a semiconductor compound or alloy comprising host atoms in a host crystal lattice with an effective bandgap that is modified by isoelectronic co-doping with more than 1at.% of a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors and more

than 1at.% of a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors to lower the effective bandgap of the semiconductor material.

Claim 31 (canceled)

Claim 32 (previously presented): The semiconductor material of claim 30, wherein content of said first isoelectronic dopant in the semiconductor compound or alloy is more than 3 at.% and content of said second isoelectronic dopant in the semiconductor compound or alloy is more than 3 at.%.

Claim 33 (original): The semiconductor material of claim 30, wherein the semiconductor alloy comprises Group III and V host atoms.

Claim 34 (original): The semiconductor material of claim 33, wherein the first isoelectronic dopant comprises Group V or Group III atoms and the second isoelectronic dopant comprises Group V or Group III atoms.

Claim 35 (original) The semiconductor material of claim 34, wherein the Group III and Group V host atoms comprise Ga and As.

Claim 36 (original): The semiconductor material of claim 35, wherein the first isoelectronic dopant comprises N and said second isoelectronic dopant comprises Bi.

Claim 37 (original): The semiconductor material of claim 34, wherein the Group III and Group V host atoms comprise In and P.

Claim 38 (original): The semiconductor material of claim 37, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 39 (original): The semiconductor material of claim 34, wherein the Group III and Group V host atoms comprise Ga and P.

Claim 40 (original): The semiconductor material of claim 39, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 41 (original): The semiconductor material of claim 34, wherein the Group III and Group V host atoms comprise Al, Ga, and P.

Claim 42 (original): The semiconductor material of claim 41, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 43 (original): The semiconductor material of claim 34, wherein the Group III and Group V host atoms comprise In, Ga, and As.

Claim 44 (original): The semiconductor material of claim 43, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 45 (original): The semiconductor material of claim 30, wherein the semiconductor alloy comprises Group II and Group VI host atoms.

Claim 46 (original): The semiconductor material of claim 45, wherein the first isoelectronic dopant comprises Group VI atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 47 (original): The semiconductor material of claim 45, wherein the first isoelectronic dopant comprises Group II atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 48 (original): The semiconductor material of claim 46, wherein the Group II and Group VI host atoms comprise Zn and Se.

Claim 49 (original): The semiconductor material of claim 48, wherein the first isoelectronic dopant comprises O and the second isoelectronic dopant comprises Te.

Claim 50 (original): A monolithic, quadruple junction solar cell, comprising:

a first cell comprising Ge with a bandgap of about 0.67 eV;

a second cell comprising GaAs that is isoelectronically co-doped with a deep acceptor element and a deep donor element to have an effective bandgap of about 1.05 eV on the first cell;

a third cell comprising GaAs with a bandgap of about 1.42 eV on the second cell; and

a fourth cell comprising InGaP with a bandgap of about 1.90 eV on the third cell.

Claim 51 (original): The monolithic, quadruple junction solar cell of claim 50, wherein a Ge substrate comprises the first cell.

Claim 52 (original): The monolithic, quadruple junction solar cell of claim 51, wherein the Ge first cell has a charge-doped n – p junction, the isoelectronically co-doped GaAs second cell has a charge-doped n - p junction, the GaAs third cell has a charge-doped n - p junction, and the InGaP fourth cell has a charge-doped n - p junction.

Claim 53 (original): The monolithic, quadruple junction solar cell of claim 52 including a p^{++} - n^{++} doped Ge tunnel junction between the first cell and the second cell, a p^{++} - n^{++} doped tunnel junction of isoelectronically co-doped GaAs between the second cell and the third cell, and a p^{++} - n^{++} doped GaAs tunnel junction between the third cell and the fourth cell.

Claim 54 (original): The monolithic, quadruple junction solar cell of claim 53, wherein the n-p junctions comprising the second and third cells are sandwiched between BSR layers, each of said BSR layers having a higher bandgap than the respective p-n junction it sandwiches.

Claim 55 (original): The monolithic, quadruple junction solar cell of claim 53, wherein the n-p junction of the fourth cell is sandwiched between a n-type AlInP window layer and a BSR layer.

Claim 56 (original): The monolithic, quadruple junction solar cell of claim 53, including a conductive bottom contact under the substrate and a conductive top contact on the fourth cell.

Claim 57 (original): The monolithic, quadruple junction solar cell of claim 35, wherein the deep acceptor element is N and the deep donor element is Bi to form GaAs:N:Bi crystal lattice.

Claim 58 (original): The monolithic, quadruple junction solar cell of claim 57 wherein content of the N in the GaAs:N:Bi crystal lattice is about 2 at.% and content of the Bi in the GaAs:N:Bi crystal lattice is about 3.8 at.%.

Claim 59 (original): A two-junction tandem solar cell, comprising:

a bottom cell comprising a Si substrate with a bandgap of about 1.1 eV and that has a charge-doped junction; and

a top cell on the bottom cell, said top cell comprising GaP that is isoelectronically co-doped with a deep acceptor element and a deep donor element to have an effective bandgap of about 1.75 eV and that has a charge-doped junction.

Claim 60 (original): The two-junction tandem solar cell of claim 59, wherein said bottom cell and said top cell are monolithic, said bottom cell has a charge-doped p-n junction, and said top cell has a charge-doped p-n junction.

Claim 61 (original): The two-junction tandem solar cell of claim 59, including a charge-doped Si tunnel junction between the Si bottom cell and the isoelectronically co-doped GaP top cell.

Claim 62 (original): The two-junction tandem solar cell of claim 60, wherein the top cell p-n junction is sandwiched between a top GaP window layer and a bottom BSR layer of GaP:N:Bi.

Claim 63 (original): The two-junction tandem solar cell of claim 62, wherein said bottom BSR layer of GaP:N:Bi has a higher bandgap than the top p-n junction.

Claim 64 (original): The two-junction tandem solar cell of claim 61, including a bottom conductive contact under the Si substrate and a top conductive contact on the top cell.

Claim 65 (original): The two-junction tandem solar cell of claim 61, wherein the deep acceptor element is N and the deep donor element is Bi to form an isoelectronically co-doped GaP:N:Bi crystal lattice that is lattice matched to the Si substrate.

Claim 66 (original): The two-junction tandem solar cell of claim 65, wherein content of the N in the GaP:N:Bi crystal lattice is about 5 at.% and content of the Bi in the GaP:N:Bi crystal lattice is about 2.2 at.%.

Claim 67 (original): A three-junction tandem solar cell, comprising:

a first cell comprising a Si substrate with a bandgap of about 1.1 eV and that has a charge-doped junction;

a second cell on said first cell, said second cell comprising GaP that is isoelectronically co-doped with a deep acceptor element and a deep donor element to have an effective bandgap of about 1.55 eV and that has a charge-doped junction; and

a third cell on said second cell, said third cell comprising GaP that is isoelectronically co-doped with a deep acceptor element and a deep donor element to have an effective bandgap of about 2.05 eV and that has a charge-doped junction.

Claim 68 (original): The three-junction tandem solar cell of claim 67, wherein the first cell has a charge-doped p-n junction, and the second cell has a charge-doped p-n junction.

Claim 69 (original): The three-junction tandem solar cell of claim 68, including a charge-doped Si tunnel junction between the Si first cell and the isoelectronically co-doped GaP second cell and also including a charge-doped tunnel junction of isoelectronically co-doped GaP between the isoelectronically co-doped GaP second cell and the isoelectronically co-doped GaP third cell.

Claim 70 (original): The three-junction tandem solar cell of claim 69, wherein the p-n junction comprising the second cell is sandwiched between BSR layers, and the p-n junction comprising the third cell is sandwiched between a top window layer and a BSR layer.

Claim 71 (original): The three-junction tandem solar cell of claim 69, including a bottom conductive contact under the Si substrate and a top conductive contact on the third cell.

Claim 72 (original): The three-junction tandem solar cell of claim 67, wherein the deep acceptor element in the second cell is N and the deep donor element in the second cell is Bi to form a GaP:N:Bi crystal lattice.

Claim 73 (original): The three-junction tandem solar cell of claim 72, wherein content of the N in the GaP:N:Bi crystal lattice of the second cell is about 5 at.% and content of the Bi

in the GaP:N:Bi crystal lattice of the second cell is about 2.2 at% of the GaP:N:Bi crystal lattice of the second cell.

Claim 74 (original): The three-junction tandem solar cell of claim 72, wherein the isoelectronically co-doped GaP:N:Bi crystal lattice of the second cell is lattice matched to the Si substrate.

Claim 75 (original): The three-junction tandem solar cell of claim 67, wherein the deep acceptor element in the third cell is N and the deep donor element in the third cell is Bi to form GaP:N:Bi crystal lattice.

Claim 76 (original): The three-junction tandem solar cell of claim 75, wherein content of the N in the GaP:N:Bi crystal lattice of the third cell is about 7 at% and content of the Bi in the GaP:N:Bi crystal lattice of the third cell is about 4.5 at%.

Claim 77 (previously presented): A method of fabricating thin film GaP semiconductor material on a Si crystal lattice, comprising:

depositing a thin film of GaP at a temperature of at least about 700 °C on the Si crystal lattice to achieve two-dimensional growth of polar GaP on non-polar Si;

prior to cooling the thin film of GaP and the Si crystal lattice to room temperature, isoelectronically co-doping the thin film of GaP with a deep acceptor element and a deep donor element in a proportion that reduces compressive misfit strain of the GaP on the Si crystal lattice; and

cooling the thin film of isoelectronically co-coped thin film of GaP and Si crystal lattice to room temperature as the misfit compressive strain reduces to a residual misfit strain of the isoelectronically co-doped GaP on the Si crystal lattice at room temperature that is of lesser magnitude than the compressive misfit strain of the GaP on the Si crystal lattice would be without such isoelectronic co-doping.

Claim 78 (original): The method of claim 77, wherein the Si crystal lattice is a miscut Si crystal lattice.

Claim 79 (canceled)

Claim 80 (original): The method of claim 77, wherein the residual misfit strain of the isoelectronically co-doped GaP on the Si crystal lattice is tensile.

Claim 81 (previously presented): The method of claim 79, including isoelectronically co-doping the GaP with sufficient deep acceptor element and deep donor element to change compressive lattice mismatch between the GaP and the Si to enough tensile lattice mismatch to offset additional compressive lattice mismatch strain that occurs while heating the Si crystal lattice and depositing GaP at a temperature of about 700 °C.

Claim 82 (original): The method of claim 81, wherein said deep acceptor element is N and said deep donor element is Bi to form GaP:N:Bi crystal lattice.

Claim 83 (original): The method of claim 82, wherein content of the N in the GaP:N:Bi crystal lattice is about 6 at.% and content of the Bi in the GaP:N:Bi crystal lattice is about 3.5 at.%.

Claim 84 (original): A method of modifying indirect bandgap GaP to act like a direct bandgap semiconductor material, comprising:

isoelectronically co-doping GaP with N and Bi to form a GaP:N:Bi crystal lattice such that content of the N in the GaP:N:Bi crystal lattice is more than 3 at.% and content of the Bi in the GaP:N:Bi is more than 2 at.%.

Claim 85 (currently amended): A light-emitting diode, comprising:

an active layer of GaP that is modified by isoelectronically co-doping <u>the</u> GaP with sufficient concentrations of N and Bi to comprise GaP:N:Bi with a lower effective bandgap in a range of about 1.55 eV to 1.93 eV, said active layer being sandwiched between: (i) a first barrier layer of [[the]] GaP charged-doped to either n-type or p-type; and (ii) a second barrier layer of GaP charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claims 86-88 (canceled)

Claim 89 (previously presented): The light-emitting diode of claim 85, wherein content of the N in the GaP:N:Bi crystal lattice is in a range of about 2 - 7 at.% and content of the Bi in the GaAs:N:Bi crystal lattice is in a range of about 2 - 7 at.%.

Claim 90 (original): The light-emitting diode of claim 89, wherein the active layer, first barrier layer, and second barrier layer are sandwiched between a n-GaP substrate window and a p-GaP superstrate window, and there is front contact on the superstrate window and a reflective back contact on the superstrate window.

Claim 91 (original): The light-emitting diode of claim 90, wherein the active layer comprises a MQW structure including multiple, alternating well layers of isoelectronically co-doped GaP:N:Bi and barrier layers of GaP.

Claim 92 (original): The light-emitting diode of claim 90, wherein the GaP substrate window has a textured surface from which light is emitted.

Claim 93 (original): The light-emitting diode of claim 89, wherein the active layer, first barrier layer, and second barrier layer are sandwiched between a Si substrate and a GaP superstrate with a step-graded layer structure disposed between the first barrier layer and the Si substrate.

Claim 94 (original): The light-emitting diode of claim 93, wherein the step-graded layer structure includes multiple layers of $GaP_{1-x-y}N_xBi_y$ with the N and Bi for each layer adjusted for desired mismatched strain between adjacent layers.

Claim 95 (original): The light-emitting diode of claim 94, wherein the step-graded layer structure includes four $GaP_{1-x-y}N_xBi_y$ layers grown consecutively over the Si substrate with the N and Bi content adjusted in each such that mismatch strain between adjacent layers of $GaP_{1-x-y}N_xBi$ is about 0.1% for the first three $GaP_{1-X-Y}N_xBi_Y$ layers and about 0.07% between the third and fourth layers of $GaP_{1-x-y}N_xBi_y$.

Claim 96 (original): The light-emitting diode of claim 93, including a distributed Bragg reflector positioned between the first barrier layer and the step-graded layer structure.

Claim 97 (original): The light-emitting diode of claim 96, wherein the distributed Bragg reflector comprises multiple, alternating layers of AlP and GaP.

Claim 98 (original): The light-emitting diode of claim 93, wherein the active layer comprises a MQW structure including multiple, alternating well layers of isoelectronically co-doped GaP:N:Bi and barrier layers of GaP.

Claim 99 (original): The light-emitting diode of claim 93, including a back contact on the Si substrate and a front contact on the GaP superstrate.

Claim 100 (original): The light-emitting diode of claim 99, wherein the front contact is a strip contact on a surface of the GaP superstrate, and wherein the surface of the GaP superstrate is textured.

Claim 101 (original): The light-emitting diode of claim 96, wherein the GaP superstrate has a recess in its surface adapted to receive and interface with an optical fiber.

Claim 102 (original): The light-emitting diode of claim 101, including an oxidized AlP isolation layer between the distributed Bragg reflector and the first barrier layer.

Claim 103 (original): The light-emitting diode of claim 85, wherein the Group III - V semiconductor compound or alloy comprises $Al_x Ga_{1-x} P$.

Claim 104 (original): The light-emitting diode of claim 103, wherein the $Al_xGa_{1-x}P$ active layer is isoelectronically co-doped with N and Bi to provide an AlGaP:N:Bi crystal lattice.

Claim 105 (original): The light-emitting diode of claim 104, wherein the active layer comprises a MQW structure including multiple, alternating well layers of isoelectronically co-doped AlGaP:N:Bi and barrier layers of AlGaP.

Claim 106 (original): A thermal voltaic cell, comprising:

an InP substrate with a bandgap of about 1.45 eV; and

a semiconductor cell deposited on the InP substrate, said semiconductor cell comprising InGaAs semiconductor alloy that is isoelectronically co-doped with N deep acceptor atoms and Bi deep donor atoms to provide an InGaAs:N:Bi crystal lattice.

Claim 107 (original): The thermal voltaic cell of claim 106, wherein the InGaAs:N:Bi has a bandgap of about 0.5 eV and which is lattice matched to the InP substrate.

Claim 108 (original): A GaAs-based laser device, comprising:

an active layer comprising GaAs that is isoelectronically co-doped with an isoelectronic atomic species that creates a deep acceptor in the GaAs and with an isoelectronic atomic species that creates a deep donor; and

a bottom cladding layer and a top cladding layer sandwiching said active layer.

Claim 109 (original): The GaAs-based laser device of claim 108, including:

a bottom separate confinement heterostructure disposed between the active layer and the bottom cladding layer; and

a top separate confinement heterostructure disposed between the active layer and the top cladding layer.

Claim 110 (original): The GaAs-based laser device of claim 109, wherein the bottom cladding layer comprises GaInP, and the top cladding layer comprises GaInP.

Claim 111 (original): The GaAs-based laser device of claim 109, wherein the bottom separate confinement heterostructure comprises GaAs, and the top separate confinement heterostructure comprises GaAs.

Claim 112 (original): The GaAs-based laser device of claim 108, wherein the active layer comprises multiple quantum wells of the isoelectronically co-doped GaAs separated by GaAs barriers.

Claim 113 (original): The GaAs-based laser device of claim 112, wherein the multiple quantum wells comprise GaAs that is isoelectronically co-doped with N and Bi.

Claim 114 (original): The GaAs-based laser device of claim 113, wherein the multiple quantum wells include In in the GaAs that is isoelectronically co-doped with N and Bi to create GaAs:N:Bi:In.

Claim 115 (original): The GaAs-based laser device of claim 108, including a GaAs substrate underlaying the bottom cladding layer.

Claim 116 (original): The GaAs-based laser device of claim 115, including a bottom contact underlaying the substrate and a top contact overlaying the top cladding layer.

Claim 117 (original): The GaAs-based laser device of claim 108, wherein the bottom cladding layer comprises a distributed Bragg reflector stack of alternating $GaAs/Al_xGa_{1-x}As$ layers and the top cladding layer comprises a distributed Bragg reflector stack of alternating $GaAs/Al_xGa_{1-x}As$ layers.

Claim 118 (original): The GaAs-based laser device of claim 117, wherein the distributed Bragg reflector stack of the bottom cladding layer has one of the $Al_xGa_{1-x}As$ as layers Al-rich and oxidized from its periphery inwardly toward an unoxidized aperture spaced inwardly from the periphery, and the distributed Bragg reflector stack of the top cladding layer has one of the $Al_xGa_{1-x}As$ layers oxidized from its periphery inwardly toward an unoxidized aperture spaced inwardly from the periphery.

Claim 119 (currently amended): A laser diode comprising:

an active region comprising a set of $Al_zGa_{1-z}P$ MQW layers that are isoelectronically co-doped with N and [[B]] <u>Bi</u> to have $Al_zGa_{1-z}P$:N:Bi with lower effective bandgaps than $Al_zGa_{1-z}P$, said MQW layers being separated by barrier layers of $Al_zGa_{1-z}P$, said active region being sandwiched between a bottom SCH layer of GaP and a top SCH layer of GaP;

a bottom cladding layer of group III - V semiconductor compound or alloy underlaying the bottom SCH layer; and

a top cladding layer of Group III - V semiconductor compound or alloy overlaying the top SCH layer.

Claims 120-121 (canceled)

Claim 122 (original): The laser diode of claim 119, wherein the Group III-V semiconductor compound or alloy of the top and bottom cladding layer comprises $Al_xGa_{1-x}P$.

Claim 123 (original): The laser diode of claim 122, wherein the bottom cladding layer is joined to a Si substrate.

Claim 124 (currently amended): The laser diode of claim 123, wherein the bottom cladding layer is joined to the Si substrate by a series of step-graded layers of $GaP_{1-x-y}N_x$ [[B_y]] <u>Bi_y</u>

with the N and Bi for each layer adjusted for desired mismatch strain between adjacent layers to accommodate 0.37% mismatch strain between the Si substrate and the $Al_xGa_{1-x}P$ bottom cladding layer.

Claim 125 (original): The laser diode of claim 124, wherein the series of step-graded layers comprises four $GaP_{1-x-y} N_x Bi_y$ layers grown consecutively over the Si substrate with the N and Bi content adjusted in each such that mismatch strain between adjacent layers of $GaP_{1-x-y} N_x Bi_y$ is about 0.1% for the first three $GaP_{1-x-y} N_x Bi_y$ layers and about 0.07% between the third and fourth $GaP_{1-x-y} N_x Bi_y$ layers.

Claim 126 (original): The laser diode of claim 125, wherein the isoelectronically co-doped Group III - V semiconductor compound or alloy of the MQW layers comprises GaP:N:Bi:In.

Claim 127 (original): The laser diode of claim 126, including a GaP surface passwation layer overlaying the top cladding layer, a top contact attached to the GaP surface passwation layer, and a bottom contact attached to the Si substrate.

Claim 128 (original): The laser diode of claim 127, wherein the Si substrate is n-type, the $Al_x Ga_{1-x} P$ bottom cladding layer is n-type, and the $Al_x Ga_{1-x} P$ top cladding layer is p-type.

Claim 129 (original): The laser diode of claim 128, wherein the bottom SCH layer is n-type and the top SCH layer is p-type.

Claim 130 (original): The laser diode of claim 127, wherein the bottom SCH layer comprises graded $Al_x Ga_{1-x} P$ in which x varies from zero adjacent the active layer to a value adjacent the bottom cladding layer that matches the $Al_xGa_{1-x}P$ of the bottom SCH layer adjacent the bottom cladding layer with the $Al_xGa_{1-x}P$ of the bottom cladding layer.

Claim 131 (previously presented): The laser diode of claim 123, wherein the top cladding layer comprises $Al_xGa_{1-x}P$, and wherein the top SCH layer comprises graded $Al_xGa_{1-x}P$ in which x varies from zero adjacent the active layer to a value adjacent the top cladding layer that matches the $Al_x Ga_{1-x} P$ of the top SCH layer adjacent the top cladding layer with the $Al_x Ga_{1-x} P$ of the top cladding layer.

Claim 132 (previously presented): A photodiode, comprising:

an active junction of Group III - V semiconductor compound or alloy comprising GaAs, which is modified to have a lower effective bandgap by isoelectronically co-doping the Group III – V semiconductor compound or alloy with sufficient concentrations of N and Bi to produce the lower effective bandgap, and which is fabricated on a substrate of Group III - V semiconductor compound or alloy.

Claim 133 (canceled):

Claim 134 (previously presented): The photodiode of claim 132, wherein the isoelectronically co-doped Group III - V semiconductor compound or alloy comprises isoelectronically co-doped GaAs:N:Bi:In.

Claim 135 (original): The photodiode of claim 134, wherein the substrate comprises GaAs.

Claim 136 (canceled)

Claim 137 (previously presented): A method of modifying a Group III – V semiconductor compound or alloy comprising Ga and As host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising:

isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors.

Claim 138 (previously presented): The method of claim 137, wherein the first isoelectronic dopant comprises Group III atoms.

Claim 139 (previously presented): The method of claim 137, wherein the second isoelectronic dopant comprises Group V atoms.

Claim 140 (previously presented): The method of claim 137, wherein the first isoelectronic dopant comprises Group V atoms.

Claim 141 (previously presented): The method of claim 137, wherein the second isoelectronic dopant comprises Group III atoms.

Claim 142 (previously presented): The method of claim 137, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 143 (previously presented): The method of claim 142, wherein content of the N in the semiconductor compound or alloy is more than 3 at.% and content of the Bi in the semiconductor compound or alloy is more than 3 at.% of the crystal lattice.

Claim 144 (previously presented): A method of modifying a Group III-V semiconductor compound or alloy comprising In and P host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising:

isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors.

Claim 145 (previously presented): The method of claim 144, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 146 (previously presented): The method of claim 145, wherein content of the N in the semiconductor compound or alloy is more than 3 at.% and content of the Bi in the semiconductor compound or alloy is more than 3 at.%.

Claim 147 (previously presented): A method of modifying a Group III-V semiconductor compound or alloy comprising Al, Ga, and P host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising:

isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic

dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors.

Claim 148 (previously presented): The method of claim 147, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 149 (previously presented): A method of modifying a Group III-V semiconductor compound or alloy comprising In, Ga, and As host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors.

Claim 150 (previously presented): The method of claim 149, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 151 (previously presented): A method of modifying a Group II-VI semiconductor compound or alloy comprising host atoms in a host crystal lattice to have a lower effective bandgap than the semiconductor compound or alloy has prior to modification, comprising isoelectronically co-doping the semiconductor compound or alloy with a first isoelectronic dopant comprising atoms that form isoelectronic electron traps in the host crystal lattice that behave as deep acceptors and with a second isoelectronic dopant comprising atoms that form isoelectronic hole traps in the host crystal lattice that behave as deep donors.

Claim 152 (previously presented): The method of claim 151, wherein the first isoelectronic dopant comprises Group VI atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 153 (previously presented): The method of claim 151, wherein the semiconductor alloy comprises Zn and Se host atoms.

Claim 154 (previously presented): The method of claim 152, wherein the first isoelectronic dopant comprises O and the second isoelectronic dopant comprises Te.

Claim 155 (previously presented): The method of claim 151, wherein the first isoelectronic dopant comprises Group II atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 156 (previously presented): The semiconductor material of claim 30, wherein the first isoelectronic dopant comprises Group V atoms and the second isoelectronic dopant comprises Group III atoms.

Claim 157 (previously presented): The semiconductor material of claim 30, wherein the first isoelectronic dopant comprises N and said second isoelectronic dopant comprises Bi.

Claim 158 (previously presented): A semiconductor material for use as an active cell in a semiconductor device, comprising:

a Group III-V semiconductor compound or alloy comprising Ga and As host atoms in a host crystal lattice that is isoelectronically co-doped with a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors, and with a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors.

Claim 159 (previously presented): The semiconductor material of claim 158, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 160 (currently amended): A semiconductor material for use as an active cell in a semiconductor device, comprising a Group III-V semiconductor compound or alloy comprising In and P host atoms in a host crystal lattice that is isoelectronically co-doped with a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors, and with a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors, and which has an effective bandgap lower than InP.

Claim 161 (previously presented): The semiconductor material of claim 160, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 162 (previously presented): A semiconductor material for use as an active cell in a semiconductor device, comprising a Group III-V semiconductor compound or alloy comprising Al, Ga, and P host atoms in a host crystal lattice that is isoelectronically co-doped with a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors, and with a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors.

Claim 163 (previously presented): The semiconductor material of claim 162, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 164 (previously presented): A semiconductor material for use as an active cell in a semiconductor device, comprising a Group III-V semiconductor compound or alloy comprising In, Ga, and As host atoms in a host crystal lattice that is isoelectronically co-doped with a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors, and with a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors.

Claim 165 (previously presented): The semiconductor material of claim 164, wherein the first isoelectronic dopant comprises N and the second isoelectronic dopant comprises Bi.

Claim 166 (previously presented): A semiconductor material for use as an active cell in a semiconductor device, comprising a Group II - VI semiconductor compound or alloy comprising host atoms in a host crystal lattice that is isoelectronically co-doped with a first isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep acceptors, and with a second isoelectronic dopant comprising atoms that form isoelectronic traps in the host crystal lattice that behave as deep donors.

Claim 167 (previously presented): The semiconductor material of claim 166, wherein the first isoelectronic dopant comprises Group VI atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 168 (previously presented): The semiconductor material of claim 166, wherein the first isoelectronic dopant comprises Group II atoms and the second isoelectronic dopant comprises Group VI atoms.

Claim 169 (previously presented): The semiconductor material of claim 166, wherein the Group II and Group VI host atoms comprise Zn and Se.

Claim 170 (previously presented): The semiconductor material of claim 166, wherein the first isoelectronic dopant comprises O and the second isoelectronic dopant comprises Te.

Claim 171 (previously presented): A method of modifying indirect bandgap GaP to act like a direct bandgap semiconductor material, comprising:

> isoelectronically co-doping GaP with N and Bi to form a GaP:N:Bi crystal lattice such that content of the N in the GaP:N:Bi crystal lattice is more than 1 at.% and content of the Bi in the GaP:N:Bi is more than 1 at.%.

Claim 172 (previously presented): A light-emitting diode, comprising an active layer of Group III - V semiconductor compound or alloy comprising GaAs that is isoelectronically co-doped with N and Bi, said active layer being sandwiched between: (i) a first barrier layer of the Group III - V semiconductor compound or alloy charged-doped to either n-type or p-type; and (ii) a second barrier layer of the Group III - V semiconductor alloy charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claim 173 (currently amended): A light-emitting diode, comprising an active layer of Group III - V semiconductor compound or alloy comprising:

> InP that is isoelectronically co-doped with a deep acceptor element and a deep donor element <u>to have a lower effective bandgap than InP</u>, said active layer being sandwiched between: (i) a first barrier layer of the Group III - V semiconductor compound or alloy charged-doped to either n-type or p-type; and (ii) a second barrier layer of the Group III - V semiconductor alloy charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claim 174 (previously presented): A light-emitting diode, comprising an active layer of Group III - V semiconductor compound or alloy comprising:

AlGaP that is isoelectronically co-doped with a deep acceptor element and a deep donor element, said active layer being sandwiched between: (i) a first barrier layer of the Group III - V semiconductor compound or alloy charged-doped to either n-type or p-type; and (ii) a second barrier layer of the Group III - V semiconductor alloy charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claim 175 (previously presented): A light-emitting diode, comprising an active layer of Group III - V semiconductor compound or alloy comprising:

InGaAs that is isoelectronically co-doped with a deep acceptor element and a deep donor element, said active layer being sandwiched between: (i) a first barrier layer of the Group III - V semiconductor compound or alloy charged-doped to either n-type or p-type; and (ii) a second barrier layer of the Group III - V semiconductor alloy charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claim 176 (previously presented): A light-emitting diode, comprising an active layer of Group III - V semiconductor compound or alloy comprising:

GaP that is isoelectronically co-doped with at least 1 at.% N and at least 1 at.% Bi, said active layer being sandwiched between: (i) a first barrier layer of the Group III - V semiconductor compound or alloy charged-doped to either n-type or p-type; and (ii) a second barrier layer of the Group III - V semiconductor alloy charged-doped to either n-type or p-type, whichever is opposite the charge-doped first barrier layer.

Claim 177 (previously presented): A photodiode, comprising:

an active junction of Group III - V semiconductor compound or alloy comprising AlGaP, which is modified to have a lower effective bandgap by isoelectronically co-doping the Group III – V semiconductor compound or alloy with sufficient concentrations of N and Bi to produce the lower effective bandgap, and which is fabricated on a substrate of Group III - V semiconductor compound or alloy.

Claim 178 (previously presented): A photodiode, comprising:

an active junction of Group III - V semiconductor compound or alloy comprising InGaAs, which is modified to have a lower effective bandgap by isoelectronically co-doping the Group III – V semiconductor compound or alloy with sufficient concentrations of N and Bi to produce the lower effective bandgap, and which is fabricated on a substrate of Group III - V semiconductor compound or alloy.

Claim 179 (previously presented): A photodiode, comprising:

an active junction of Group III - V semiconductor compound or alloy comprising InP, which is modified to have a lower effective bandgap by isoelectronically co-doping the Group III – V semiconductor compound or alloy with sufficient concentrations of N and Bi to produce the lower effective bandgap, and which is fabricated on a substrate of Group III - V semiconductor compound or alloy.

Claim 180 (previously presented): A photodiode, comprising:

an active junction of Group III - V semiconductor compound or alloy comprising GaP, which is modified to have a lower effective bandgap by isoelectronically co-doping the Group III – V semiconductor compound or alloy with at least 1 at.% N and at least 1 at.% Bi to produce the lower effective bandgap, and which is fabricated on a substrate of Group III - V semiconductor compound or alloy.